Usability and utility of a mobile application for marksmanship training

Stuart C. Grant
Nada Pavlovic
DRDC – Toronto Research Centre

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IMPORTANT INFORMATIVE STATEMENTS

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The data collected as part of this study was approved either by Defence Research and Development Canada's Human Research Ethics Board or by the Director General Military Personnel Research & Analysis' Social Science Research Review Board.

Abstract

Mobile learning and embedded training technologies are being fielded by military organizations to ensure that learners can access training material anytime and anywhere. Recent advances in learning technologies and future weapon concepts offer the potential to offer anytime, anywhere training to new skill domains. The potential of these technologies to improve small arms coaching skills was investigated to test the willingness of soldiers to utilize anytime, anywhere self-directed training and to determine the utility and usability of embedding small arms coaching training in future weapons.

In this experiment soldiers were first tested on their ability to identify shooting errors depicted in videos before they were issued with either a paper or digital small arms coaching training aid. The soldiers then retained the training aid for five days and were instructed to review the training material to prepare for a final test. At the final test session soldier reported they seldom used the training aid, yet their error detection ability improved. The gain was attributed to the testing effect of watching the videos, and interpreted as providing some evidence for the efficacy of digital media for training small arms coaching skills. The limited use of the training aids during the intervening period indicates that soldiers will not necessarily conduct anytime, anywhere self-directed training.

Usability questionnaires and focus group discussions indicate that the soldiers prefer a combination of paper and digital small arms coaching training aids. It is recommended that a prototype small arms coaching aid be developed and that social support be provided where self-directed learning is expected of soldiers.

Significance to defence and security

Small arms coaching is a skill that all members of the Canadian Armed Forces must demonstrate in the Annual Personal Weapons Test. Increasing the supply of skilled small arms coaches would obtain better value from existing training resources and provide the potential for reduced training costs or higher marksmanship performance.

The multi-media content for small arms coaching training was demonstrated to significantly improve the ability to diagnose shooting errors. Soldiers will not necessarily use mobile learning technologies to conduct self-directed training on their own time, however. If the Canadian Armed Forces makes greater use of self-directed learning and mobile learning, the technology should be accompanied by social supports that motive soldiers to use the technology.

Résumé

Les technologies d'apprentissage électronique sans fil et d'instruction intégrée sont déployées sur le terrain par les organisations militaires afin de s'assurer que les apprenants puissent avoir accès au matériel d'instruction en tout temps et n'importe où. Les progrès récents dans les technologies d'apprentissage et les concepts d'armes futures permettent d'offrir n'importe où n'importe quand une formation dans de nouveaux domaines de compétence. Nous avons étudié le potentiel qu'ont ces technologies d'améliorer les compétences pédagogiques de tir à l'arme légère dans le but de tester l'empressement des soldats à pratiquer l'autoformation n'importe où, n'importe quand et de déterminer l'utilité et l'utilisabilité d'intégrer la formation d'instructeur de tir à l'arme légère, pour les futures armes.

Lors de cette expérience, les soldats ont été évalués quant à leur capacité à cerner les erreurs de tir dans des vidéos avant de recevoir le matériel de formation d'instructeur de tir à l'arme légère, en copie papier ou en version numérique. Les soldats ont conservé ce matériel pendant cinq jours et avaient reçu la directive de le passer en revue pour se préparer à l'épreuve finale. Lors de cette épreuve, les soldats ont indiqué qu'ils avaient rarement utilisé le matériel, mais leur capacité à cerner les erreurs s'était améliorée. Cette amélioration était attribuable à l'effet du test de visionnement des vidéos et considérée comme une preuve de l'efficacité des médias numériques sur les compétences pédagogiques au tir d'armes légères. L'usage limité du matériel d'instruction lors de cette période intermédiaire indique que les soldats ne suivront pas nécessairement une autoformation n'importe où n'importe quand.

Les questionnaires et les discussions des groupes témoins sur l'utilisabilité indiquent que les soldats préfèrent une combinaison de matériel d'instruction sur papier et numérique pour la formation d'instructeur de tir à l'arme légère. Il est recommandé d'élaborer un prototype de matériel pédagogique pour les instructeurs de tir à l'arme légère et d'offrir un soutien social lorsque les soldats sont censés suivre une autoformation.

Importance pour la défense et la sécurité

L'instructeur de tir à l'arme légère possède une compétence que tous les membres des Forces armées canadiennes doivent démontrer lors de l'épreuve annuelle de tir à l'arme personnelle. Accroître le nombre d'instructeurs de tir à l'arme légère expérimentés permettrait d'optimiser les outils pédagogiques existants et de réduire potentiellement les coûts de formation ou d'obtenir de meilleures performances de tir.

Le contenu multimédia de la formation d'instructeur de tir à l'arme légère a démontré qu'il améliorait considérablement la capacité de cerner les erreurs de tir. Toutefois, les soldats n'utiliseront pas nécessairement les technologies d'apprentissage sans fil pour s'assurer une autoformation durant leurs temps libres. Si les Forces armées canadiennes pratiquent davantage l'autoformation et l'apprentissage sans fil, la technologie devrait être accompagnée de mesures de soutien social qui encouragent les soldats à utiliser la technologie.

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1 Introduction

The Canadian Army anticipates acquiring a new generation of carbines, rifles, and machine guns. This new generation of small arms could include technologies that have not been previously applied to small arms, such as computerized fire control and target sharing. These new technologies are expected to substantially increase the effectiveness of the weapon and soldier. To assist with this acquisition, Defence Research and Development Canada's project on Future Small Arms is examining the implications of these emerging technologies for Canadian Army operations (Harris, Levesque, Andrukaitis, & Laou, 2013; Tack & Angel, 2014).

If new small arms technologies are provided for use by soldiers, they will likely require additional skills to employ them (Papaz, Angel, & Thomson, 2013). However, soldiers and units frequently report that they have difficulty conducting the existing amount of training (Tack, Nakaza, & Osborne, 2013). Scheduling groups of trainees and instructors, drawing weapons and ammunition from stores, travel to training facilities, support personnel, and clean-up, for example, contribute to the cost and difficulty of conducting marksmanship training. Substituting a central simulation facility for a live fire range, can reduce some, but not all of these overheads. If training soldiers to use the new technologies demands greatly increased training resources, this demand could compromise the introduction of future small arms into the Canadian Armed Forces (CAF). Ideally the new technologies should make training faster and easier.

Defence Research and Development Canada (DRDC)'s Future Small Arms Research (FSAR) project is investigating the potential of utilizing the computing, sensing, and display capabilities expected in the future weapon to provide embedded training (ET) in the new weapon (Angel & Tack, 2013; Bruyn-Martin & Brown, 2013). ET provides the opportunity to train in the absence of centralized, dedicated training facilities and equipment. In this way training can take place wherever and whenever the training audience and circumstances allow (Bruyn-Martin & Brown, 2013; Finley, Alderman, Peckham, & Strasel, 1988; NATO, 2009).

The ability of ET to provide computer-based training independent of location is similar to training applications ("apps") provided on mobile computing devices. Like ET, apps have the potential to enable learning anytime, anyplace and do not entail the same overhead as more centralized, synchronous training (BenMoussa, 2003; Virvou & Alepis, 2005). The ability to train using the time available between other scheduled events (informally termed "hurry up and wait" in military parlance) is one reason why mobile learning is seen as beneficial for military training audiences (Department of the Army, 2011; Haag, 2011). Guidance for military use of mobile learning, and particularly in infantry contexts, is less common (Tucker, 2010), however. It is known that the context of mobile device use is critical to its usability (Biel, 2010), but the available guidance for mobile learning is typically derived from experiences in academic or commercial contexts (Ally, 2009; Kukulska-Hulme, 2007; Motiwalla, 2007). The US Army Research Institute Keller-Glaze, H., Horey, J., Nicely, K., Brusso, R., Miller Nihill, M., & Cobb, M. G., 2013) and a community of practice (Advanced Distributed Learning Initiative, 2013) have produced advice for the development of mobile learning for military populations, but the advice is not aimed at the infantry soldier in the field. The infantry context, such as limited or no connectivity, greatly varying environmental lighting, exposure to weather and dirt, vibration, rough handling, and fatigued users have not been systematically assessed as influences on the design of a mobile application (Tucker, 2010). Research on ET for dismounted soldiers has aimed at fielding

ambitious integrated soldier systems and not at marksmanship specifically (Dumanoir, Garrity, Lowe & Witmer, 2002; Dyer, 2009; Knerr, Garrity & Lampton, 2004).

To inform the CAF on the suitability of ET apps as a way to train the use of future small arms, an experiment was performed to assess the utility, or effectiveness, of a digital marksmanship coaching application, either as a learning tool or as a job aid. Small arms coaching was selected because it may be needed more widely if small arms training is to be conducted away from specialized marksmanship training facilities and instructors. Moreover, marksmanship coaching skill does not depend on training the motor skills of marksmanship (Proctor & Woodman, 2007), but rather the cognitive aspects (Chung, Nagashima, Espinosa, Berka, & Baker, 2009a, 2009b) and so could be embedded into both the weapon or any other computing device issued to soldiers.

2 Method

In this experiment soldiers used an app, a booklet, or only their background knowledge, to identify shooting errors committed by a soldier depicted in video clips. It was hypothesized that soldiers will be more accurate in identifying shooting errors using the app and the booklet than with only their background knowledge. To assess the likelihood that soldiers will use anytime - anywhere training, the usage of the devices was tracked over the course of a week. It was hypothesized that having constant access to the learning content, along with an imminent opportunity to use the knowledge, would result in frequent use of the paper and electronic versions of the material. Finally, the experiment used questionnaires and a focus group to investigate the usability of marksmanship apps, with attention to the infantry context.

2.1 Participants

Forty six regular force male infantry and combat engineer soldiers participated in the study during the experimental campaign held at DRDC Toronto 17 January to 7 March. Twenty three soldiers were from 1 Battalion, Royal Canadian Regiment (RCR), three from 1 Battalion, Combat Engineering Regiment (CER), 10 from 2 Battalion RCR, and 10 from 2 Battalion CER. The sample consisted of four privates, 34 corporals, four master corporals, and four sergeants. All had normal or corrected to normal vision, as assessed by Snellen tests (6/6m or better). All were Personal Weapons Test (PWT) three or four qualified (Department of National Defence, 2007). Thirty (65%) had operational experience in Afghanistan, and 21 (46%) had actually engaged the enemy.

These participants were all tasked by their chain of command to report to DRDC Toronto for one week for the purpose of voluntary participation in various experiments and studies as described in Protocol 2013-065 *Omnibus Protocol for all Studies Run during the Winter 2014 Troops Tasking at DRDC Toronto*. They were informed that they could withdraw from the experiment at any time.

2.2 Apparatus

An electronic version of the Rifle Marksmanship Diagnostic and Training Guide (James & Dyer, 2011) developed by the Canadian Defence Academy was delivered on Apple iPad Mini devices provided by the investigators. The printed version of the guide was presented in a spiral-bound format (Figures 1 and 2).

Figure 1: *Apple iPad Mini.*

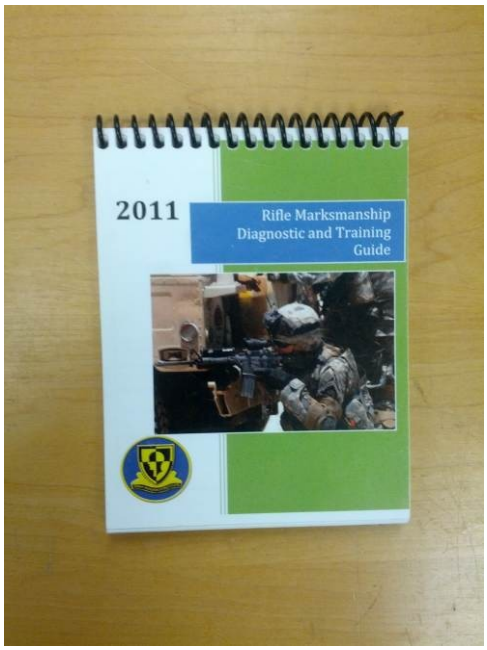

Figure 2: *Spiral-bound booklet.*

To measure the ability to detect marksmanship errors, a list of 36 shooting errors was compiled from the Rifle Marksmanship Diagnostic and Training Guide (James & Dyer, 2011) and used to produce the Shooting Error Checklist presented in Annex A. Corresponding test material was produced in the form of videos clips. The video clips depicted the shooting errors identified in the

guide as well as error-free shooting. The videos were recorded in a studio and edited by a professional videographer using 1080p High Definition video and audio format. One right-handed and one left-handed Canadian Army small arms instructors agreed to demonstrate the errors in video recording. A small arms expert from the Canadian Army coached the models to ensure that the desired error and only the desired error was demonstrated in each clip. The soldiers used an operational weapon, modified with a compressed gas system that would cycle the action of the weapon, produce a small amount of noise, and produce recoil forces when the trigger was pulled. In each clip the soldier fired five times, and the duration of each clip was approximately 15 seconds. A total of 131 video clips were produced, depicting the shooting errors committed by right-handed and left-handed shooters. The errors were also demonstrated in both the prone and kneeling position, with the exception of errors that were specific to a particular posture. The videos were then reviewed by four small arms instructors using the Shooting Error Checklist. The judges showed substantially greater agreement than would be expected by chance, as measured by Fleiss' Kappa, $\kappa_{observed} = 0.524$, $\kappa_{expected} = 0.037$. Only clips where the same error identification was assigned by three or four of the judges were retained for use in the experiment.

The videos were presented on Sharp PNL702B 70-inch LED monitors.

Three questionnaires were used to evaluate the usability of the both the printed and digital versions of the guide. The first was Brooke's (1996) System Usability Scale, which is a validated (Bangor, Kortum, & Miller, 2008) instrument that provides a very quick characterization of the usability of any technological system. They also completed a subset of the Mobile Phone Usability Questionnaire (Ryu & Smith-Jackson, 2005) which is a validated (Ryu & Smith-Jackson, 2006) instrument that asks detailed questions about mobile phone usability. Questions that pertained solely to mobile telephones, e.g., ringtones, were not included in the version presented to the subjects. The final questionnaire was the Context and Feature questionnaire. This questionnaire is a checklist and a free form instrument developed for this experiment from Jumisko-Pyykko's and Vainio's (2011) model of mobile computing context. The purpose of the questionnaire was to identify the circumstances where infantry soldiers might use paper or digital learning materials. These questionnaires are presented in Annex B.

2.3 Procedure

Visual acuity, contrast sensitivity, and colour vision data were collected under protocol 2013-073: Automated Target Cueing in Scene Search (Dr. Mackenzie Glaholt, DRDC Toronto Research Centre) and shared with the principal Investigator of this study. The demographic data were collected under protocol 2013-071: Effect of Load, Bulk and Stiffness of Soldier Equipment on Physical Performance: Canadian Load Effects Assessment Program (CAN-LEAP) (Dr. Michel Ducharme, DRDC Toronto Research Centre) and shared with the principal Investigator of this study.

The experiment consisted of two experimental sessions which took place in a meeting room in DRDC Toronto. The participants were tested in groups of up to 10. One group of participants was tested each week for six weeks. Table 1 provides an overview of the experimental procedure.

Table 1: *Overview of procedure.*

Session 1 (Monday)	**4 Day Interval**	**Session 2 (Friday)**
Introduction and informed consent	Participants retain guide and review at their convenience	View Marksmanship Videos (job aid test, with guide)
View Marksmanship Videos (pre-training test, no guide)		View Marksmanship Videos (post training test, no guide)
Guide Familiarization and information retrieval task		Mobile Phone Usability Questionnaire System Usability Scale Context Questionnaire
View Marksmanship Videos (job aid test, with guide)		Focus Group
Dismissal with instructions to review guide when convenient		Debrief & Dismiss
End Session 1		End Session 2

The first session, conducted on the Monday morning of the participant's week at DRDC Toronto, began with a verbal explanation of the experiment. The participants were provided with an information package and consent form explaining participation in this experiment and their right to withdraw their consent. All the questions were answered at this point. No participants withdrew from the experiment.

The participants then viewed 16 video clips on large screen display to assess their pre-existing knowledge of shooting errors. In some of the clips the soldier's technique was correct and in most the soldier made one or more errors identified in the guide. Each clip (see Figure 3) was presented at least twice and would be repeated again if a subject asked to see it again. The participants were instructed to use the Shooting Error Checklist to indicate which, if any, shooting errors were present in the video.

Figure 3: *A frame from a video clip depicting the rifle not resting at V of thumb and palm.*

Following the video clips, the participants were issued the guide, either in a printed or a digital form (on an iPad Mini), which they retained for the week. The purpose and features of the guide were explained by a small arms expert from the Canadian Army. To familiarize them with the guide, they were directed to browse through various sections and required to find specific information. This familiarization specifically included the sections of the guide that dealt with the identification of shooting errors. To militate against potential bias or instructional style changes on the part of the small arms expert, the duration of the browsing activity was set at 15 minutes and the same search topics were used for both formats. In addition, the expert was cautioned against using evaluative statements when describing the guide. The differences in the methods of navigation through the two formats prevented an absolutely identical familiarization treatment, however. These precautions reduce, but cannot guarantee elimination of any instructional style or variations between formats on the part of the small arms expert.

The participants then viewed another set of 16 video clips, this time with the instruction that they could use the guide as a job aid in identifying the errors. These were all new clips, but depicting the same set of errors. The participants again used the multiple choice sheet in Annex A to indicate which, if any, errors they observed. The participants were then told that they should retain the guide for review at their convenience to prepare for the second session of the experiment. They were then dismissed.

The second session of the experiment commenced on the Friday. The participants were first asked to report how many times they used the guide for five or more minutes each day during the intervening period. They were then instructed to again use the guide as a job aid while evaluating another 16 video clips. At the end of this task they returned their guides to the experimenter. The utility of the guide as a training aid was then tested by asking the participants to report shooting

errors in a final set of 16 video clips. The video clips used in the Friday session were the same video clips used in the Monday session, although they were presented in a new order.

Following the video clip portion of the session, the soldiers completed the usability questionnaires and participated in a focus group facilitated by a Canadian military arms expert, according to the protocol in 0. A research made written notes during the discussion. At the conclusion of the focus group, the participants were debriefed on the experiment and dismissed.

3 Results

All subjects completed the experiment, with a total of 20 subjects in the groups receiving the booklet version of the guide and 26 subjects in the groups receiving the digital version. The difference in the number of subjects receiving each format of the guide arose due to the availability of subjects and testing constraints. The differing sizes of the groups were not under the control of the experimenters and laboratory resource limitations required that all subjects in a group be tested with the same format of the guide.

3.1 Usage

The subjects reported very little use of the guide between the experiment sessions. Subsequently, most subjects did not use it at all. A repeated measures analysis of variance shows that there was not a reliable difference in booklet and digital guide usage, $F_{(1,44)} = 2.09$, $p > .05$. There was a strong effect of repeated tests, $F_{(4,176)} = 24.71$, $p < .001$. The interaction was not significant, $F_{(4,176)} = 0.83$, $p > .05$. A planned comparison was performed to test for a linear trend. The contrast was significant, $F_{(1,44)} = 38.09$, $p > .001$, indicating that usage declined during the week. Inspection shows usage of both the printed guide (Figure 4) and digital guide (Figure 5) was most frequent on Monday, when nearly all subjects used the guide at least once, and most did not refer to it again during the week.

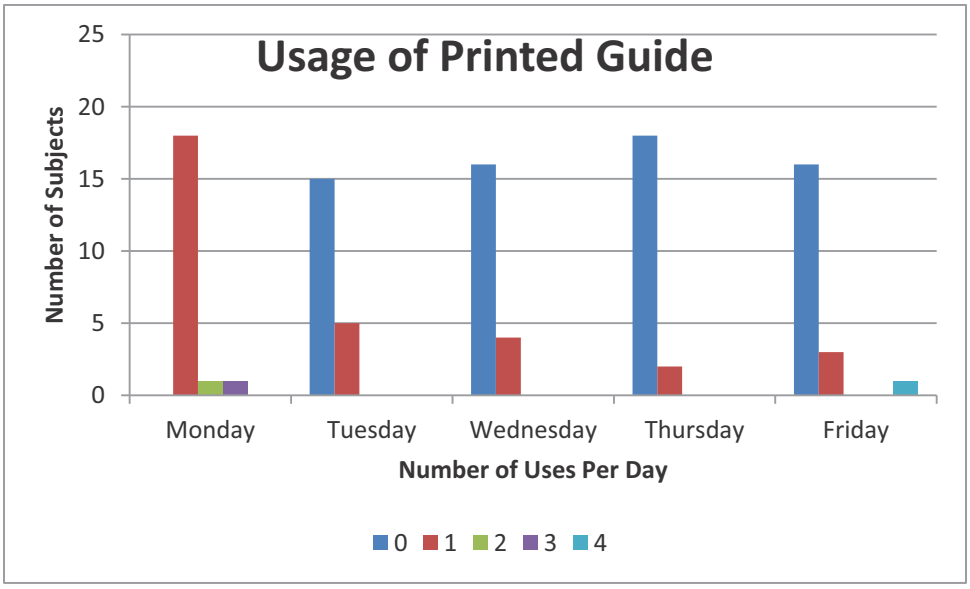

Figure 4: *Number of soldiers reporting how often they used the printed guide each day.*

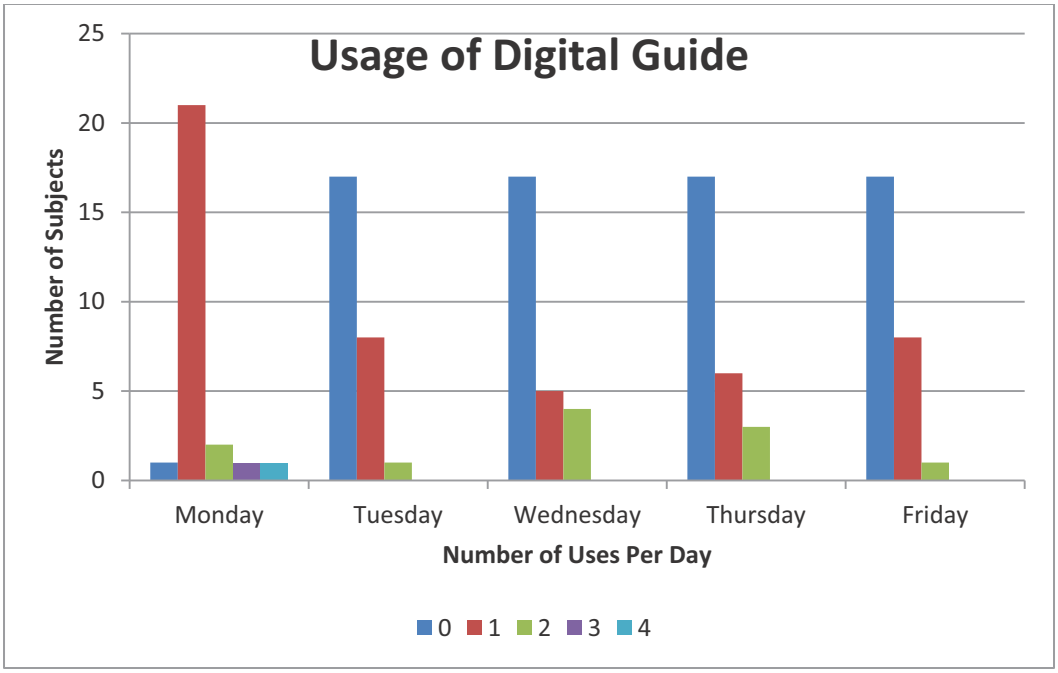

Figure 5: *Number of soldiers reporting how often they used the digital guide each day.*

3.2 Utility as a job aid

The experimenters observed that the subjects did not use the guide, in either printed or digital form, as a job aid when it was available and when they were encouraged to do so. Consequently, the data from the testing sessions intended to measure the guide's utility as a job aid did not bear upon the utility of the guide as a job aid and so this analysis was not performed.

3.3 Utility as a training aid

The proportion of correct video judgements, depicted in Figure 6, were analyzed using repeated measures analysis of variance with guide media type (booklet versus digital) as a between subjects factor and testing event (pretest, job aid test 1, job aid test 2, post-test) as a within subjects factor. The analysis revealed that there was no main effect of guide type, $F_{(1,32)} = 0.621$, $p > .05$ and no effect of testing event $F_{(3,96)} = 1.947$, $p > .05$. The overall interaction did not reach significance, $F_{(3,96)} = 0.377$, $p > .05$. A planned comparison revealed that performance on the post-test was significantly better than performance on the pre-test, $F_{(1,32)} = 5.07$, $p < .05$, but a planned comparison of the pre-post improvement of the booklet group to the digital group revealed no significant difference, $F_{(1,32)} = 0.689$, $p > .05$.

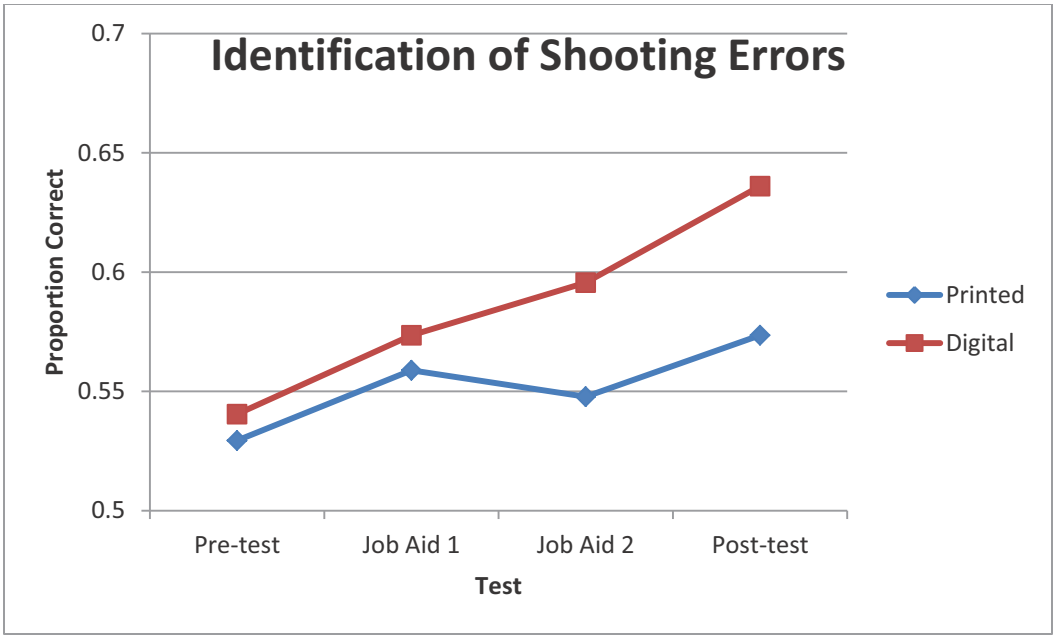

Figure 6: *Proportion of correctly identified shooting errors.*

3.4 Usability

The Mobile Phone Usability Questionnaire scores for each group were computed by calculating scores for each of the sub-scales. The scores for the printed and digital guides were compared using t-tests. The mean scores differed only on the Commands and Memory Load sub-scale, $t_{(42)} = 3.86$, $p < .001$, where the digital version of the guide was seen as being a better system (mean rating of 5.58 vs 4.46 on a scale where 1 = strongly disagree and 7 = strongly agree).

The System Usability Scale scores were compared using a t-test for independent samples. Both versions of the guide received moderately positive ratings (mean score of 67.84 for the printed version and 75.79 for the digital version on a scale ranging from zero to 100). A t-test for independent groups found that these ratings were not significantly different, $t_{(42)} = 1.68$, $p > .05$.

3.5 Focus group

Six focus groups were conducted. Following from Sim's (1998) observation that focus group results are indicative of the collective discussion, rather than multiple individuals, the data from each focus group were treated as a single observation. This seems especially suitable because the groups consisted of formed units with an intact rank structure and differential levels of experience with small arms coaching. The notes from the discussions were then reviewed to derive categories of responses to the focus group protocol questions. The frequencies of each response type were then counted across each focus group to provide a simple content frequency analysis (Onwuegbuzie, Dickinson, Leech, & Zoran, 2009). Annex C presents the categorized responses to the discussion topics along with the frequencies of each response. The maximum possible frequency is 6, which indicates that the response was provided by all focus groups.

All groups believe there was a need for a small arms coaching training aid. Three of the six groups also felt there was not a need because the material was available elsewhere. The groups were also unanimous in their desire for a single version of the training aid that would be subdivided into sections for novices and advanced users. They believed that all different types of users (e.g., Navy, reservists, instructors) would be served by either the novice or advanced sections of a unified training aid. When asked whether a training aid should be in paper or digital format, four groups desired it in both formats, with one group preferring paper and one group preferring digital. The most commonly desired features in a digital training aid were a glossary, information on how to correct shooting errors, and to embed the training aid in a modular soldier's mobile application that would address other topics such as additional weapons, navigation, and communications. All these features were identified by three different groups. Finally, the four of the groups were emphatic that a training aid should not be used to reduce their range time and three groups were similarly adamant that a digital application is an aid to, and not a substitute for, an experienced and competent instructor.

Three themes emerged from the focus group discussions. First, the soldiers were nearly unanimous in seeing a need for a coaching application on a mobile device. They generally saw the mobile device as reference material for those with direct responsibility for coaching. They were adamant that the device be simply an aide memoire, and that it should not serve as a substitute for a fully qualified coach. Second, they expected that a mobile device version of the guide would be more than a digital document. They believed that multimedia depictions of correct behaviour, incorrect behaviour, and remedial interventions would be significant enhancements to the guide. In addition, they envisioned that such a guide would be part of a suite of similar infantry reference material residing on the mobile device. The third theme was sensitivity to the strengths and weaknesses of printed and digital materials. Digital devices were seen as powerful but fragile, expensive and power-limited whereas printed materials were seen as durable, cheap, and reliable with limited capabilities relative possible digital systems. Most focus groups did not see these differences as grounds for a choice between formats, but rather as guidance for selecting from both available formats according to their immediate circumstances.

4 Conclusion

The experiment examined the use and effect of immediately available small arms coaching training material with the goal of understanding the effectiveness of this type of training if it were delivered as part of a training capability embedded in a future rifle. A second goal was to determine if soldiers would avail themselves of the anywhere – anytime training capability that would be provided by embedded training. A final goal was to understand the usability of the systems provided examined.

The soldiers did not use the training capability outside the experiment. They had the guide with them for five days and four nights while they were at DRDC Toronto. Their scheduled participation in several experiments each day provided them with regular periods where they were not otherwise engaged. They were away from their home station so they had no obligations in the evening. Even with the knowledge that they would again be tested on marksmanship errors on the Friday of the week, most soldiers looked at the guide only once on Monday and not again. This finding does not support the idea that soldiers will spontaneously engage in self-study if provided with the materials and time. The reason they did not do so is unclear. It may be they believed they already mastered the material, that the material was not valuable, or that they were not motivated to learn the material. The implication of this result is that the mere provision of training capability in an embedded or mobile device is not sufficient to produce learning and that the early expectations in this regard (BenMoussa, 2003; Virvou & Alepis, 2005) may not be easily realized. Soldiers will not automatically use personal or spare work time to train. Direction and motivation are still required.

The soldiers did not use the guide as a job aid to assist them during the actual task when given the opportunity to do so, despite their imperfect ability to identify the shooting errors.

The soldier's identification of shooting errors became more accurate over the course of the two tests provided on Monday and the two tests on Friday. Given that they did not make substantial use of the guide between the pairs of tests, it is apparent that learning occurred as a result of the testing itself, a phenomenon called the testing effect (Roediger & Karpicke, 2006). Consequently, the results obtained do not provide evidence regarding the efficacy of the guide as presented in digital and paper form. However, the nature of the tests developed from the guide, the videos of errors with the instruction to detect the error, is exactly the kind of multimedia training material that would be delivered in an embedded or mobile training device. As such, this provides strong evidence of the effectiveness of this approach to training small arms coaching.

Usability questionnaire data revealed that the simple digital guide was found to be at least as usable as the printed version. The implication is possible to provide embedded or mobile training material to dismounted soldiers satisfactorily.

Finally, it was found that soldiers were receptive to using a digital training guide for small arms coaching but they are wary that the introduction of a digital training aid might be used as justification to reduce their time on the range or to provide unqualified coaches.

4.1 Recommendations

On the basis of the preceding findings, the following recommendations are made.

4.1.1 Evaluate a prototype mobile application for marksmanship coaching

A prototype mobile application for marksmanship coaching should be developed for the Army. Developed in consultation with Canadian Army small arms experts and trainers, the application should be provided to a group of soldiers slated to undertake small arms instruction training. The experiment would record their usage of the system and their performance on the small arms instruction course for comparison to a similar group not provided with the mobile learning application. Ideally an additional group would be provided with a paper version of the training aid to determine if the computing capabilities of the mobile device assist in training. The practical benefit of this action will be to improve army marksmanship coaching. A secondary benefit would be a better understanding of the circumstances of when and where soldiers will use embedded or mobile training applications. This knowledge would further inform instructional design decisions by Training Development Officers, enabling them to develop more efficient training.

4.1.2 Field embedded or mobile training systems with performance support

To ensure independent use of embedded or mobile training systems, many soldiers may require support in the form of direction of when and why to train as well as motivation to do so. If this is not done in conjunction with the issuing of the training capability, such as being loaded on a formal course, it may be beneficial to provide informal structure and motivation. Recent research describes how this might be accomplished using online discussion groups or peer mentoring (Boyle, Kwon, Ross, & Simpson, 2010).

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Annex A Shooting error checklist

Error	1	2	3	4	5	6	7	8
Firing Hand / Arm								
Canted rifle								
Butt not tight against shoulder								
Firing elbow horizontal (“chicken wing”)								
Firing hand too loose								
Firing hand too tight								
Firing hand too low on pistol grip								
Fingertip on trigger								
Slapping and releasing trigger								
Trigger finger canted up or down								
Trigger finger position causes rotated wrist								
Non - Firing Hand / Arm								
Non-firing hand too tight								
Rifle passively resting on non-firing hand								
Rifle not resting at V of thumb and palm								
Bone-to-bone or flesh-to-flesh on knee								
Excess wobble of muzzle								
Supporting & Control Arm								
Elbows too close together								
Elbows too far apart								
Head								
Raising head between shots								
Raised head to look at target								
Inconsistent head position								
Not looking through center of firing eye								
Flinching								
Closed eyes during firing								
Legs								
Legs not at 90˚ (kneeling)								
Legs bowed (prone)								
Non-Firing leg cocked (prone)								
On toes (prone)								
Torso								
Breathing while firing								
Over - breathing								
Natural point of aim not aligned with target								
Not directly behind rifle								
Not leaning forward								
Buttocks not resting on firing side foot as much as possible								
Equipment improperly worn								
Armour / helmet interference								
Whole Body								
Fidgeting								
No error								

Figure A.1: *The shooting error checklist.*

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Annex B Usability instruments

Table B.1: *The abbreviated version of the mobile phone usability questionnaire (Ryu 7 Smith-Jackson, 2005).*

Mobile Phone Usability Questionnaire (Abbreviated)

Please circle the best answer.

Galaxy Tab **Apple iPad** **Apple iPad Mini** **Samsung Large Tablet**

Circle the device you used.

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is it easy to learn to operate this product?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is using this product sufficiently easy?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Have the user needs regarding this product been sufficiently taken into consideration?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is it relatively easy to move from one part of a task to another?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Can all operations be carried out in a systematically similar way?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Are the operations of this product simple and uncomplicated?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Does this product enable the quick, effective, and economical performance of tasks?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is it easy to access the information that you need from the product?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the organization of information on the product screen clear?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Does product have all the functions and capabilities you expect it to have?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Are the color coding and data display compatible with familiar conventions?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is it easy for you to remember how to perform tasks with this product?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the interface with this product clear and understandable?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Are the characters on the screen easy to read?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Does interacting with this product require a lot of mental effort?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Can you regulate, control, and operate the product easily?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is it easy to navigate between hierarchical menus, pages, and screen?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the backlighting feature for the keyboard and screen helpful?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Are the command names meaningful?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is discovering new features sufficiently easy?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the HELP information given by this product useful?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the presentation of system information sufficiently clear and understandable?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is it easy to take corrective actions once an error has been recognized?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is feedback on the completion of tasks clear?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Does the product give all the necessary information for you to use it in a proper manner?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the bolding of commands or other signals helpful?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Does the HELP function define aspects of the product adequately?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is this product's size convenient for transportation and storage?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is using this product frustrating?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is this product attractive and pleasing?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Do you feel comfortable and confident using this product?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Does the color of the product make it attractive?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Does the brightness of the product make it attractive?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Are pictures on the screen of satisfactory quality and size?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the number of colors available adequate?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Are the components of the product are well-matched or harmonious?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Do you feel excited when using this product?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Would you miss this product if you no longer had it?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Are you/would you be proud of this product?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Does carrying this product make you feel stylish?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the organization of the menus sufficiently logical?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the design of the graphic symbols, icons and labels on the icons sufficiently relevant?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Does the product provide index of data?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the highlighting on the screen helpful?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Are the HOME and MENU buttons sufficiently easy to locate for all operations?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Are the response time and information display fast enough?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Has the product at some time stopped unexpectedly?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the amount of information displayed on the screen adequate?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the way product works overall consistent?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the data display sufficiently consistent?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Does the product support the operation of all the tasks in a way that you find useful?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is the product reliable, dependable, and trustworthy?

Strongly Disagree						Strongly Agree
1	2	3	4	5	6	7

Is it sufficiently easy to operate keys with one hand?

Table B.2: *The system usability scale (Brooke, 1996).*

System Usability Scale

Participant # _____

Please respond to the following statements about the Marksmanship Guide by marking the box that most closely matches your opinion (1 = strongly disagree; 3 = neither agree nor disagree; 5 = strongly agree)

1. I think that I would like to use this system frequently	Strongly Disagree ☐ 1	☐ 2	☐ 3	☐ 4	Strongly Agree ☐ 5
2. I found the system unnecessarily complex	Strongly Disagree ☐ 1	☐ 2	☐ 3	☐ 4	Strongly Agree ☐ 5
3. I thought the system was easy to use	Strongly Disagree ☐ 1	☐ 2	☐ 3	☐ 4	Strongly Agree ☐ 5
4. I think that I would need the support of a technical person to be able to use this system	Strongly Disagree ☐ 1	☐ 2	☐ 3	☐ 4	Strongly Agree ☐ 5
5. I found the various functions in this system were well integrated	Strongly Disagree ☐ 1	☐ 2	☐ 3	☐ 4	Strongly Agree ☐ 5
6. I thought there was too much inconsistency in this system	Strongly Disagree ☐ 1	☐ 2	☐ 3	☐ 4	Strongly Agree ☐ 5
7. I would imagine that most people would learn to use this system very quickly	Strongly Disagree ☐ 1	☐ 2	☐ 3	☐ 4	Strongly Agree ☐ 5
8. I found the system very cumbersome to use	Strongly Disagree ☐ 1	☐ 2	☐ 3	☐ 4	Strongly Agree ☐ 5
9. I felt very confident using the system	Strongly Disagree ☐ 1	☐ 2	☐ 3	☐ 4	Strongly Agree ☐ 5
10. I needed to learn a lot of things before I could get going with this system	Strongly Disagree ☐ 1	☐ 2	☐ 3	☐ 4	Strongly Agree ☐ 5

Table B.3: *The context and feature questionnaire.*

Context and Feature Questionnaire

Participant #_____

Please describe the **two most useful** contexts for using a publication for marksmanship.

Context Example: At the beach	**Context 1:**	**Context 2:**
Goal ☑ Study by an small arms user ☐ Study by a small arms instructor ☐ While coaching a buddy ☐ While providing small arms instruction Other:	**Goal** ☐ Study by an small arms user ☐ Study by a small arms instructor ☐ While coaching a buddy ☐ While providing small arms instruction Other:	**Goal** ☐ Study by an small arms user ☐ Study by a small arms instructor ☐ While coaching a buddy ☐ While providing small arms instruction Other:
Location ☐ Indoors ☑ Outdoors ☐ Vehicle	**Location** ☐ Indoors ☐ Outdoors ☐ Vehicle	**Location** ☐ Indoors ☐ Outdoors ☐ Vehicle
Type ☐ Residential ☐ Work / School ☑ Recreational / Entertainment Other:	**Type** ☐ Residential ☐ Work / School ☐ Recreational / Entertainment Other:	**Type** ☐ Residential ☐ Work / School ☐ Recreational / Entertainment Other:
Environment ☑ Very bright ☐ Dark ☑ Wet ☑ Dirty / Dusty ☐ Hot ☐ Cold ☑ Comfortable temperature ☑ Noisy ☐ Very Quiet Other:	**Environment** ☐ Very bright ☐ Dark ☐ Wet ☐ Dirty / Dusty ☐ Hot ☐ Cold ☐ Comfortable temperature ☐ Noisy ☐ Very Quiet Other:	**Environment** ☐ Very bright ☐ Dark ☐ Wet ☐ Dirty / Dusty ☐ Hot ☐ Cold ☐ Comfortable temperature ☐ Noisy ☐ Very Quiet Other:
Movement ☑ Stationary ☐ Walking ☐ Moving in vehicle	**Movement** ☐ Stationary ☐ Walking ☐ Moving in vehicle	**Movement** ☐ Stationary ☐ Walking ☐ Moving in vehicle
Other tasks ☐ Simultaneous ☐ Switching ☑ No other tasks Other task:	**Other tasks** ☐ Simultaneous ☐ Switching ☐ No other tasks Other task:	**Other tasks** ☐ Simultaneous ☐ Switching ☐ No other tasks Other task:
Duration per use ☐ Less than 5 min ☑ 5-9 min ☐ 10-14 min ☐ 15 -19 min ☐ 20 min or more	**Duration per use** ☐ Less than 5 min ☐ 5-9 min ☐ 10-14 min ☐ 15 -19 min ☐ 20 min or more	**Duration per use** ☐ Less than 5 min ☐ 5-9 min ☐ 10-14 min ☐ 15 -19 min ☐ 20 min or more
Time when used ☐ Before work ☐ At work ☐ During breaks ☑ After work	**Time when used** ☐ Before work ☐ At work ☐ During breaks ☐ After work	**Time when used** ☐ Before work ☐ At work ☐ During breaks ☐ After work
Sequence ☐ Before other task ☐ During other task ☐ After other task ☑ Not sequenced Other task:	**Sequence** ☐ Before other task ☐ During other task ☐ After other task ☐ Not sequenced Other task:	**Sequence** ☐ Before other task ☐ During other task ☐ After other task ☐ Not sequenced Other task:
Social Situation ☐ Nobody else present ☐ Strangers present ☑ Amongst family / friends ☐ Amongst co-workers ☐ Interactively with others	**Social Situation** ☐ Nobody else present ☐ Strangers present ☐ Amongst family / friends ☐ Amongst co-workers ☐ Interactively with others	**Social Situation** ☐ Nobody else present ☐ Strangers present ☐ Amongst family / friends ☐ Amongst co-workers ☐ Interactively with others
Infrastructure ☐ WiFi available ☐ Wide –area wireless network ☑ Personal device ☐ Device provided through work	**Infrastructure** ☐ WiFi available ☐ Wide –area wireless network ☐ Personal device ☐ Device provided through work	**Infrastructure** ☐ WiFi available ☐ Wide –area wireless network ☐ Personal device ☐ Device provided through work

Features and Suggestions

Please write down your thoughts on what would make a marksmanship mobile app or booklet easy to use and effective. Changes to the system you have used and suggestions for new features are welcome.

Some possible topics:

- Booklet or mobile device physical characteristics (size, finish, etc)
- Learning Content (e.g. less material, more theory, less theory, longer, shorter)
- Graphics (videos, more pictures, etc)
- Organization of the content
- Who should use it, and when, and where.
- Differences of where a booklet or an app would be better

Annex C Focus group data summary

Table C.1: *Focus group response frequencies.*

Topic	Responses	Frequency
Is there a need for a small arms coaching training aid?	Yes	6
	No	3
	Information is already available elsewhere	3
Are there different individuals who need the training aid?	There should be a single version with different sections for novice and advanced users	6
Does the need for such a training aid differ between instructors or is it for all soldiers?	There should be a single version with different sections for novice and advanced users	3
Does the need for such a training aid differ between combat arms and those not in the combat arms?	Same version for all	2
	There should be a single version with different sections for novice and advanced users	3
Does the need for such a training aid differ between the regular forces and the reserves?	Same version for all	2
Do the air force or navy need for such a training aid	Yes	5
At what stage in a soldier's career is a small arms coaching training aid needed?	Right from the start	3
	Only needed when they advance in rank	1

Topic	Responses	Frequency
Should the training aid be provided in a paper or digital format?	Paper	5
	Digital	5
When is one format better than another?	Paper is more durable (dirt, weather)	2
	Digital devices are fragile	2
	Paper does not need power	2
	Digital needs power	2
	Paper documents are easy to issue to soldiers	2
	Digital devices are difficult to issue to soldiers	2
	Digital content is easy to obtain	2
	Paper content is difficult to obtain	1
	Paper documents bring weight and bulk	2
	Digital for clean conditions, e.g., classroom	2
	Paper for rugged conditions, e.g., field	2
	Digital may have less appeal to older soldiers	1
	Digital may have more appeal to younger soldiers	2
What features are needed in a digital	Glossary	3

Topic	Responses	Frequency
training aid?	Make the coaching training application a module in a larger soldier application that would include information on other weapons, map reading, navigation, etc.	3
	Show how to correct shooting errors	3
	Provide 3D / 360 degree view of firers	2
	Use moving images to depict correct and incorrect shooting	2
	Provide an efficient search function	2
	Enable use of the device camera for capturing and debriefing performance of the firer	2
	Add close quarter battle techniques	1
	Address physiology / stress of shooting	1
	Adjusting sights	1
	Availability on DWAN	1
	Ballistics data for space beyond the target	1
	Ballistics data for target effects /penetration	1
	Care of weapons in weather	1
	Different sections for trainer / trainee	1

Topic	Responses	Frequency
	Discuss acceptable personal variations in shooting technique	1
	Entertaining features and soldier-friendly language	1
	Explain grouping and zeroing	1
	Label images with information indicating correct or incorrect technique	1
	Left handed firer coaching information	1
	Range estimation techniques	1
	Shot analysis information	1
	Specifics of combat shooting as compared to range shooting	1
	Video of how rifle works	1
	Wind / weather effects on shooting	1
What should not be included?	CQB should be treated separately	2
	Do not provide excess information	3
How should the training aid you used be modified?	Canadianize the content	3
	Observe digital device conventions like swiping to turn pages	2
Are there other things to offer or other	No excuse to take away range time	4

Topic	Responses	Frequency
considerations?	Should not be a crutch or substitute for competent and qualified instructors	3
	Make available for use in downtime	1

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Annex D Focus group protocol

Table D.1: *Focus group protocol.*

1 Introduction	Thank you for completing the questionnaires. For the final part of this experiment, I would like to lead a discussion on your thoughts about using a mobile app or booklet to help with marksmanship knowledge. This is a chance for us to discuss some of the ideas you have come up with on your own.
2 Ground Rules (2 minutes)	Before we begin, I would like to review a few ground rules for the discussion. • I am going to ask you several questions; we do not have to go in any particular order but we do want everyone to take part in the discussion. We ask that only one person speak at a time. • Feel free to treat this as a discussion and respond to what others are saying, whether you agree or disagree. We're interested in your opinions and whatever you have to say is fine with us. We are just asking for your opinions based on your own personal experience. We are here to learn from you. • Don't worry about having a different opinion than someone else. But please do respect each other's answers or opinions. • We are taking notes because we don't want to miss any of your comments. • Does anyone have any questions before we start?
3 Group Discussion – Who Needs This? (10 minutes)	The first question is whether there is a need for an app or a booklet to help people identify shooting errors. • Is there a need for it? • Are there different people with different needs? • Individual soldiers? • Small Arms Instructors? • Combat vs Non-Combat Arms? • Air Force and Navy? • Regular vs Reserves? • At what stage in their military career?
4 Group Discussion - What format? (5 minutes)	Our next topic is the format of the material. This could be produced as a booklet or an app. The booklet is always usable and is does not need power or a device, but takes space and weight. An app can provide multimedia and other features, and has no space or weight if you already have a device. • What do you think is better? • When is one better than another?
5 Group Discussion - What features?	Our final topic is to think about what a version for the CAF should be like. • If you were building it, what would you want in it?

(15 minutes)	• What should it not include? • How should the one you tried be modified?
6 Final Thoughts	That is the end of my questions. • Are there any other things you would like to offer or other things that should be considered?
7 Wrap up	Thanks for participating in the discussion. That brings us to the end of the experiment. [DEBRIEF AND DISMISS]

List of symbols/abbreviations/acronyms/initialisms

CAF	Canadian Armed Forces
CAN-LEAP	Canadian Load Effects Assessment Program
CER	Combat Engineer Regiment
CQB	Close Quarter Battle
DRDC	Defence Research and Development Canada
DWAN	Defence Wilde Area Network
ET	Embedded Training
FSAR	Future Small Arms Research
PWT	Personal Weapons Test
RCR	Royal Canadian Regiment

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Toronto, Ontario M3K 2C9
Canada

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Mobile learning and embedded training technologies are being fielded by military organizations to ensure that learners can access training material anytime and anywhere. Recent advances in learning technologies and future weapon concepts offer the potential to offer anytime, anywhere training to new skill domains. The potential of these technologies to improve small arms coaching skills was investigated to test the willingness of soldiers to utilize anytime, anywhere self-directed training and to determine the utility and usability of embedding small arms coaching training in future weapons.

In this experiment soldiers were first tested on their ability to identify shooting errors depicted in videos before they were issued with either a paper or digital small arms coaching training aid. The soldiers then retained the training aid for five days and were instructed to review the training material to prepare for a final test. At the final test session soldier reported they seldom used the training aid, yet their error detection ability improved. The gain was attributed to the testing effect of watching the videos, and interpreted as providing some evidence for the efficacy of digital media for training small arms coaching skills. The limited use of the training aids during the intervening period indicates that soldiers will not necessarily conduct anytime, anywhere self-directed training.

Usability questionnaires and focus group discussions indicate that the soldiers prefer a combination of paper and digital small arms coaching training aids. It is recommended that a prototype small arms coaching aid be developed and that social support be provided where self-directed learning is expected of soldiers.

Les technologies d'apprentissage électronique sans fil et d'instruction intégrée sont déployées sur le terrain par les organisations militaires afin de s'assurer que les apprenants puissent avoir accès au matériel d'instruction en tout temps et n'importe où. Les progrès récents dans les technologies d'apprentissage et les concepts d'armes futures permettent d'offrir n'importe où n'importe quand une formation dans de nouveaux domaines de compétence. Nous avons étudié le potentiel qu'ont ces technologies d'améliorer les compétences pédagogiques de tir à l'arme légère dans le but de tester l'empressement des soldats à pratiquer l'autoformation n'importe où, n'importe quand et de déterminer l'utilité et l'utilisabilité d'intégrer la formation d'instructeur de tir à l'arme légère, pour les futures armes.

Lors de cette expérience, les soldats ont été évalués quant à leur capacité à cerner les erreurs de tir dans des vidéos avant de recevoir le matériel de formation d'instructeur de tir à l'arme légère, en copie papier ou en version numérique. Les soldats ont conservé ce matériel pendant cinq jours et avaient reçu la directive de le passer en revue pour se préparer à l'épreuve finale. Lors de cette épreuve, les soldats ont indiqué qu'ils avaient rarement utilisé le matériel, mais leur capacité à cerner les erreurs s'était améliorée. Cette amélioration était attribuable à l'effet du test de visionnement des vidéos et considérée comme une preuve de l'efficacité des médias numériques sur les compétences pédagogiques au tir d'armes légères. L'usage limité du matériel d'instruction lors de cette période intermédiaire indique que les soldats ne suivront pas nécessairement une autoformation n'importe où n'importe quand.

Les questionnaires et les discussions des groupes témoins sur l'utilisabilité indiquent que les soldats préfèrent une combinaison de matériel d'instruction sur papier et numérique pour la formation d'instructeur de tir à l'arme légère. Il est recommandé d'élaborer un prototype de matériel pédagogique pour les instructeurs de tir à l'arme légère et d'offrir un soutien social lorsque les soldats sont censés suivre une autoformation.

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training; small arms; mobile learning; marksmanship